CONTAINER CLOSURE

This invention relates to the field of container closures. In one non-limiting aspect, the invention relates to the field of container closures for pressurised products, such as pressurised beverages.

Conventionally, pressurised beverages such as lemonade and beer are contained in bottles which have a screw threaded closure or a crimped metal closure. Generally, the closures are of only a small diameter (typically less than 42 mm). This is because the amount of force exerted on the closure by the pressurised contents will depend on the area of the closure. It is theoretically possible for a larger size of screw-threaded closure to be used, but this would have to be tightened so firmly on the bottle that it would be extremely difficult for a person to unscrew it by hand. Accordingly, there has to be a compromise between the size of the closure, the force which the closure can withstand, and the ability of a person to remove the closure by hand.

Generally, for pressurised beverages, the internal pressure within the bottle can reach pressures of 100 psi. Such high pressures may, for example, be reached during hot pasteurisation of the bottle after filling. During storage at room temperature, the internal pressure is likely to be less than about 40 psi (and a closure might be rated to withstand a pressure of at least 60 psi). Nevertheless, the closure may have to be able to withstand much higher pressures.

In one aspect, it would be desirable to provide a closure which does not suffer from the above drawbacks, and is better able to be used for wide-mouth containers.

In contrast to the prior art, one aspect of the present invention is to provide a closure having engagement means for engaging the mouth of the container and removable means for bracing the engagement means to hold it in a locked position.

Preferably, the bracing means comprises a band which embraces the engagement means to prevent the engagement means from being displaced radially outwardly.

Preferably, the engagement means comprises one or more lugs which locate or hook under an undercut or projection of the container, to secure the closure in position.

With the above design, the lugs may, for example, locate under a rim, or in a recess, around the mouth of the container, to form a snap fit. The band embracing the lugs prevents the lugs from slipping out of the engagement, even if the cap is subjected to extremely high forces. However, when it is desired to release the closure, it is a relatively simple matter to remove the band. With the band removed, the lugs are free to slide out from the recess as the closure is lifted, or peeled off the container mouth.

Preferably, the band is hingedly attached to the closure. To remove the band from its bracing position, the band is lifted, so that it hinges upwardly. In that condition, the band can then provide a convenient handle to allow the closure to be peeled from the container mouth.

If desired, the closure may be designed to be re-fittable to the container mouth by reversing the above process. Alternatively, the closure may be designed to make the band difficult (or even impossible) to refit into its bracing position. This can provide a closure with improved tamper-proof protection.

Preferably, the band is integrally moulded with the remainder of the closure. More preferably, the band is joined (at least initially) to the engagement means by one or more frangible connections. These connections can provide a further tamper-evident feature, and can also ensure that the band is held securely in its bracing position until the closure is removed by the user for the first time.

Preferably, at least one (preferably all) of the frangible connections is in the form of a tapered ridge, which is relatively wide at the point of contact with the engagement means, and tapers towards the point of contact with the band. This can ensure that the fracturing of the frangible connection occurs at a pre-determined point (the narrowest point). The remainder of the bridge then also serves as a spacer to hold the band off the surface of the engagement means, and to maintain the band in tension.

Although the engagement means may be in the form of a continuous lug or rim, it is preferred that the engagement means be in the form of lug segments. Such segmenting can enable the lugs to move outwardly independently of each other, and therefore allow the closure to be fitted to, and removed from, the container mouth more easily.

In one form, the closure is configured to allow a predetermined one or more lugs to flex outwardly to vent internal container pressure during initial opening of the closure, without causing immediate disengagement of other lugs. This can reduce the chances of the closure potentially blowing off the container mouth when the bracing effect is removed.

Preferably, the closure is configured such that the bracing effect is released or relaxed firstly for the predetermined lug or lugs before other lugs, when the bracing means (for example a band) is moved or relaxed.

Preferably, one or more lugs adjacent to the one or more predetermined lugs are configured to interrupt or obstruct any peeling effect caused by flexing of the predetermined lug or lugs. In other words, the lugs are configured such that, when the predetermined lug flexes, this does not result in uncontrolled peeling of the other lugs from around the container mouth.

In one form, this is achieved by providing a space or discontinuity in the engagement means. For example, the lugs adjacent to the predetermined lug may have circumferentially shorter engagement surfaces to provide the discontinuity.

In another form, a mechanical interlock is provided between the bracing band and at least some of the lugs. Preferably, a mechanical interlock is provided to each lug (other than to lugs at, or adjacent to, the hinge region). The mechanical interlock serves to communicate the bracing tension in the band directly to each lug. Therefore, even when the band is progressively lifted (hinged) upwardly so that it does not provide the same complete embracing effect around the entire periphery of the closure, the mechanical interlock can maintain a direct bracing effect for each lug when it is mechanically interlocked to the band. As the band is lifted progressively, the number of lugs locked to the band decreases, to provide a progressive release of the bracing effect around at least a portion of the periphery of the closure.

Preferably, a pull-loop or tab is provided on the bracing means to facilitate pulling on the bracing means by a finger, or gripping of the bracing means.

The present invention is especially suitable for use with wide mouth containers. As defined herein, the term "wide mouth" refers to container mouths having a lateral dimension (e.g. diameter) of at least about 4 cm, more preferably at least about 4.5 cm,

and more preferably at least about 5 cm. The invention can be used for even larger container mouth sizes, for example, at least about 6 cm, at least about 7 cm, at least about 7.5 cm, or even larger, e.g. for paint tins.

Although the invention is applicable to wide mouth containers, the invention is equally suitable for use on conventional size container mouths, for example of 20mm-45mm in diameter, to replace a conventional screw threaded closure. A problem with conventional screw threaded closures, especially for pressurised contents, is that the plastics closure must be sufficiently rigid to prevent bowing of the upper wall of the closure under internal pressure. Such bowing would tend to tighten and distort the screw threaded engagement, making it virtually impossible to unscrew the closure to remove it. With conventional screw threaded closures, such rigidity is achieved by using relatively thick plastics walls, which requires a relatively larger amount of plastics material.

In contrast, the present invention does not suffer from the same disadvantages under pressure. In fact, stressing of the closure can improve the seal between the closure and the container mouth. Therefore, the closure can be manufactured with relatively thin plastics walls, requiring significantly less plastics material than the screw threaded closures. Such improved manufacturing economy can provide a closure which may be less expensive to use even for relatively small container mouth sizes.

In a closely related specific aspect, the invention provides a closure having engagement means for engaging the mouth of a container, and removable bracing means for bracing the engagement means to hold it in a locked condition, the bracing means being integral with the engagement means (or with a body portion of the closure) when the closure is fitted in an operative secured position on a conatiner.

In a closely related further aspect, the invention provides a closure having engagement means for engaging the mouth of a container, and removable bracing means for bracing the engagement means to hold it in a locked condition, the bracing means being hingedly coupled to the closure.

In a closely related further aspect, the invention provides a closure for a wide-mouthed container, the closure having engagement means for engaging the mouth of

the container, and removable bracing means for bracing the engaging means to hold it in a locked condition.

In a closely related further aspect, the invention provides a pressure-retaining closure for a pressurised container, the closure comprising engagement means for engaging the mouth of the container, and removable bracing means for bracing the engagement means to hold it in a locked condition.

In a closely related further aspect, the invention provides a container closure having engagement means for engaging the mouth of the container, and removable bracing means for bracing the engagement means to hold it in a locked condition, the bracing means comprising means for facilitating a progressive release of the bracing effect around at least a portion of the engagement means.

In a closely related further aspect, the invention provides a container closure having engagement means for engaging the mouth of the container, removable bracing means for bracing the engagement means to hold it in a locked condition, and means for anchoring the bracing means relative to the engagement means to limit the extent to which the bracing means can move and/or stretch relative to the engagement means.

This can increase the strength of the bracing effect, for example, when the closure is withstanding a large pressure.

The anchoring may, for example, be provided by a mechanical interlock. Additionally, or alternatively, the anchoring may be achieved by frangible connections (provided that these are able to withstand torsional loads).

In a closely related further aspect, the invention provides a container closure having engagement means for engaging the mouth of the container, and removable means for bracing the engagement means to lock it in a locked condition, the bracing means being attached directly or indirectly to the engagement means in such a manner that the bracing means is peelable progressively from the engagement means to release said locked condition progressively.

Embodiments of the invention are now described by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1 is a perspective view from above of a wide-mouth container with a closure fitted;

Fig. 2 is a perspective view from below of the closure in isolation;

Fig. 3 is a schematic underside view showing the detail of the closure;

Fig. 4 is a partial section showing fitting of the closure to the container mouth;

Fig. 5 is a partial section showing the engagement of the closure on the container mouth;

Fig. 6 is a perspective view similar to Fig. 2 but showing the band in its released condition;

Fig. 7 is a schematic view of a second embodiment of closure;

Fig. 8 is a schematic section showing possible modification of the closure;

Fig. 9 is a perspective view showing a further embodiment of container and closure;

Fig. 10 is an underside view of the closure of Fig. 9 in isolation;

Fig. 11 is an enlarged view showing a detail of Fig. 9;

Fig. 12 is a section along the line XII-XII of Fig. 11;

Fig. 13 is a schematic section showing a detail of the initial lug and pull-loop;

Fig. 14 is a schematic section showing disengagement of the initial lug when the pull-loop is lifted;

Fig. 15 is a perspective underside view of a further embodiment of closure;

Fig. 16 is an underside plan view of the closure of Fig. 15;

Fig. 17 is a schematic section showing a further embodiment of closure, and a two-part mould for moulding the closure;

Fig. 18 is a schematic plan view showing a detail of the frangible connections of the closure of Fig. 17;

Fig. 19 is a schematic section similar to Fig. 17 but showing the upper mould part lifted away;

Fig. 20 is a schematic section showing the closure just prior to fitting to a container mouth;

Fig. 21 is a schematic drawing similar to Fig. 20 but showing the closure in its fully fitted position over the container mouth;

Fig. 22 is a schematic drawing similar to Fig. 18, but showing the frangible connections in a collapsed state when the closure is in its fitted position;

Fig. 23 is a schematic section showing the closure being ejected from the lower mould part;

Fig. 24 is a schematic section showing the closure after moulding; and

Fig. 25 is a schematic illustration of a yet further embodiment.

Referring to Figs. 1 to 6 of the drawings, a glass or plastics container 10 is illustrated for a pressurised beverage. The present embodiment is intended to contain a beer, cider, or carbonated soft drink, and is shaped in the form of a glass. The container 10 has a wide mouth opening 12, which is typically about 6 cm in diameter. A fastening rim 11 projects around the mouth opening 12. The rim has a curved upper surface 11a, and a more abrupt undercut surface 11b.

The container is sealed by means of a plastics press-on closure 14. The closure 14 consists of a generally flat upper wall 16 with a rounded rim 18. Depending from the rim 18 are a plurality of segmented lugs 20. In the present embodiment, the closure includes fourteen such lugs 20.

Each lug 20 includes on its inner face a snap fit projection 22 which is dimensioned to engage under the rim 11 around the mouth of the container 10. Each projection 22 has curved lead-in ramp surface 26 shaped to match the profile of the rim surface 11a. Each projection 22 also has a more abrupt abutment surface 28 which forms the engagement with the undercut surface 11b of the rim 11

The closure 14 also includes an integral band 30 which is attached in this embodiment to one of the lugs by a non-frangible hinge web 32. The band 30 is also integrally attached to each of the other lugs 20 by a plurality of frangible connections 34; in this embodiment, there are about 5 connections per lug 20. As will be described below, the band 30 braces the lugs 20 to prevent the lugs from moving outwardly and thus secures the lugs in a "locked" condition.

As best seen in Figs. 3 and 4, the radially outer surface of each lug is moulded with an arrangement of generally parallel, axially extending ridges 35. The frangible connection 34 is in the form of a thin breakable web extending between a ridge 35 and the band 30. The ridges 35 serve to reinforce the lugs 20, and are also significant for moulding the closure 14. In particular, if the ridges were not present, then a very thin mould tool tongue would be required to fit between the bracing band 30 and the lugs

20. Such a thin tongue would be extremely vulnerable to damage by movement of the mould parts, and would not be expected to have a long working life. In contrast, with the current ridged design, additional space is provided between the bracing band 30 and the lugs 20 to enable a stronger tongue (which is thicker between the ridges) to be employed during moulding.

As is conventional, a non-permeable liner 24 will typically be provided on the inner surface of the closure, to improve the seal, and to act as a barrier layer to prevent the transpiration of the beverage gas through the plastics material of the closure. Such liners are known in the art, particularly when the closure is made from plastics such as polypropylene. However, in contrast to many conventional screw threaded closures which have to employ low friction liner material (to suit rotation of the closure), the present embodiment is not limited by this constraint because it does not employ a turning action. Therefore, the liner material may, if desired, be a relatively high friction seal material. The liner material may be inserted into the closure after the moulding process, or may be injected into the closure as part of the moulding process (e.g. 2-shot moulding, or insert moulding).

Referring to Figs. 3 and 4, to fit the closure 14 to the container 10, a fitting head (not shown) is used. The closure 14 is initially placed on the container mouth rim 11, as shown in Fig. 4. The matching profiles of the rim surface 11a and the projection ramp surface 26 ensure that closure can sit squarely on the rim 11 prior to fitting, so that the closure 14 is not applied skew to the container 10. The fitting head presses downwardly on the closure 14 to force the closure over the rim 11. During the fitting processes, the lugs 20 will be forced outwardly slightly as the snap-fit projections 22 pass over the container rim 11. The band 30 may stretch to some extent to accommodate this outward movement of the lugs 20.

When fitted, the band 30 locks the lugs 20 securely behind the rim 11 of the container mouth, to securely fasten the closure in position. The closure 14 is able to withstand large forces from the internal pressure of the beverage, even during processes such as hot pasteurisation. As best seen in Fig. 4, a seal is established between the closure 14 and the container 10 at the rounded rim section 18 of the closure 14. If the internal pressure within the container increases, this tends to tension

the upper wall 16 of the closure, thus increasing the sealing force applied between the closure 14 and the container at the rounded corner region 18.

The abutment surface 28 of each lug 22 and the undercut surface 11b of the rim 11 may have complementary small inclinations, for example, about 10° relative to a plane perpendicular to the container axis. Such an inclination provides two effects:

(a) during fitting of the closure 14 to the container rim 11 (both initially as described above, or when re-applying the closure as described later), the inclined surfaces provide a cam effect to pull the closure 14 downwardly on to the mouth as the lugs spring back to engage behind the rim 11. This provides additional sealing force, and also accommodates a degree of tolerance variation in the precise sizes of the closure 14 and the container mouth;

(b) during removal of the closure 14 (described below), the inclined surfaces permit easy removal of the closure 14 by lifting it.

In order to remove the closure 14, a person has simply to apply finger pressure to lift the band 30, as shown in Fig. 6. Such action causes the frangible connections 34 to tear, but the band 30 remains attached to the remainder of the closure by virtue of the hinge web 32.

With the band 30 lifted out of engagement with the lugs 20, the closure 14 can now be lifted, or peeled, from the container mouth with very little force being required. The lugs are able to slip over the rim 11 around the container mouth, and the small inclination of the abutment surfaces 28 of the lugs facilitates this disengagement. The raised band 30 provides a convenient handle which can be pulled to lift the closure 14 from one edge. It will be appreciated that segmenting of the lugs 20 also aids removal of the closure 14, by allowing the closure to flex, and also allowing the lugs to move outwardly independently of each other.

If desired, the closure 14 can be refitted to the container 10 after use simply by a reverse of the opening steps. With the band in a raised condition, the closure can be snapped into position over the rim 11 of the container mouth. The band 30 can then be lowered into its bracing position around the lugs, to re-lock the lugs in tight engagement with the rim 11.

Although frangible connections might not be provided in all embodiments, the connections do provide the following advantages in the preferred embodiment:

(a) The connections enable simple moulding of the removable band as an integral part of the closure, using a single moulding step;

(b) Prior to opening, the connections act as a tamper evident feature of the closure;

(c) Prior to opening, the connections positively hold the band in position to prevent risk of accidental opening.

Fig. 7 illustrates a slightly modified form of closure 14' in which the generally flat upper wall 16 of the first embodiment is replaced by a slightly dome-shaped wall 38. Such a shape may provide additional strength, and also reduce the stress experienced at the rounded corner region 18 of the closure when the closure is subjected to very high internal container pressures. However, for some applications, the more "square" shape of the closure of the first embodiment may nevertheless be preferred, for example, for ease of stacking or packaging.

In the above embodiments, the band remains integrally attached to the remainder of the closure once the band is lifted from its bracing position. It will be appreciated that in other embodiments, the band may be completely removable, and might be removed by tearing the band open. The band could, for example, be in the form of a strong filament or plastics film provided that it is capable of providing the necessary bracing effect to lock the closure in its closed position.

Depending on the design of the closure, the use of the segmented lugs 20 might in some cases provide a fail-safe feature for high pressure container contents. With any closure, there is always a danger that if the internal container pressure is too great, the closure might be "blown" off the container mouth. By using segmented lugs, the closure could be designed such that that one or a limited number of the lugs will fail under pressure before the others, leaving a gap through which the high pressure can escape. This can reduce the risk of the closure being blown off completely.

Fig. 8 illustrates other possible modifications of the closure to reduce the risk of the closure blowing off once the band 30 is released. It will be appreciated that one or more of these modifications may be combined, as desired.

As shown in phantom at 22, one or more of the locking projections 22 may be lengthened in a radial direction, so that it provides a greater degree of engagement with the rim of the container mouth.

Additionally, or alternatively, as shown at 20', one or more of the lugs 20 may be lengthened in an axial direction, so that the respective locking projection is spaced axially below the container mouth rim when the closure is in its fully closed position. In this condition, the lug 20' does not contribute to the fastening of the closure on the container mouth. However, as the closure tends to lift (for example, if the closure is tending to be blown off the container mouth once the band 30 has been removed), the tooth of the extended lug 20' provides a second-stage of engagement to obstruct free removal of the closure.

A further possibility is that, as indicated at 35', the ridges on the surface of each lug could be extended to provide additional stiffening of the lug. The stiffer lugs would then provide a more secure engagement with the container mouth once the band 30 had been removed.

Figs. 9-14 show a further embodiment of closure, designed to be easy to open, yet also to vent safely internal pressure from within the container. This embodiment is similar to the first embodiment described above, and the same reference numerals are used where appropriate to denote equivalent features.

Referring to Figs. 9 and 10, the band 30 is formed with an integral finger-loop or pull-loop 40 at a position diametrically opposite the hinge web 32 (or at a position opposite the effective "centre" if more than one hinge web is used). The pull-loop 40 is dimensioned to enable a person's finger to be passed through the loop 40, or to enable it to be gripped easily by a finger and thumb. The loop 40 serves three functions:

(a) it provides an easy way of gripping the band 30 to lift the band;

(b) it ensures that the band 30 will always be lifted by a force applied at a predetermined location diametrically opposite the hinge web 32; and

(c) as a safety feature, if the user passes his finger through the loop 40, it can ensure that the closure will not blow freely off the container mouth if the internal

pressure has risen above anticipated levels which the closure is designed to accommodate.

The lugs 20a and 20b in the vicinity of the pull-loop 40 are modified compared to the profile of the first embodiment, to provide control over the manner in which the lugs are released when the band 30 is lifted. As best seen in Figs. 10 and 11, the lug 20a diametrically opposite the hinge web 32 (i.e. and in register with the pull-loop 40) is referred to as the "initial" lug, and is modified to ensure that it will be released from engagement by the band 30 before any of the other lugs 20. To achieve this, the ridges 35a are shortened in an axial direction, such that they do not extend significantly above the level of the band 30. Therefore, when the band 30 begins to lift (when the closure is opened), it will release the bracing effect on the ridges 35a of the initial lug 20a before releasing the bracing effect on any other lugs. Therefore, the internal pressure within the container will be able to vent around the released initial lug 20a.

The lugs 20b immediately either side of the initial lug 20a are modified to have circumferentially shorter snap-fit projections 22b which are spaced away from the lug 20a. Generally, the projections 22b will be between 25% and 90% of the circumferential dimension of the lug 20b, typically between 50% and 75%, for example about 66%. The shortened projections 22b have three effects:

(a) Firstly, the short projections 22b tend to interrupt or reduce the peeling effect when the initial lug 20a is disengaged from the container rim. This can allow the initial lug 20a to be lifted significantly without "peeling" the adjacent lugs 20b.

(b) Secondly, the shortening of the projections 22b leaves a region around the initial lug 20a in which there is no interlocking engagement with the container rim 11. This has the effect of increasing the loading force on the initial lug 20a relative to the other regularly spaced lugs, to further ensure that the initial lug 20a will disengage first from the rim 11.

(c) Thirdly, the region of non-interlocking engagement around the initial lug 20a provides room for the closure to distort, to provide a vent path around the initial lug 20a. It will be appreciated that, were the lugs 20b to interlock with the container rim 11 at positions too close to the initial lug 20a, then this might have the undesirable

effect of clamping the closure tightly against the rim 11 in the region of the initial lug 20a, and hence obstruct any venting.

The manner in which the initial lug is disengaged is illustrated in Figs. 13 and 14. In Fig. 13, the pull-loop 40 is shown in its normal un-opened position in which it lies flat against, or close to, the initial lug 20a. Referring to Fig. 14, when the pull-loop 40 is lifted (to release the band 30), the initial effect is for the band 30 to move above the short ridges 35a of the initial lug 20a (although the band 30 will remain bracing the ridges of the other lugs). Prior to the frangible connections 34 beginning to break, the lifting of the pull-loop 40 also twists the initial lug 20a outwardly, to release the engagement of the snap-fit projection 22a carried by the initial lug, and allow the container pressure to be vented. The internal pressure can distort the closure in the region 42 when the lug 20a is disengaged, to provide the vent path between the closure and the container rim 11. (Although only a single lug is described and illustrated for the sake of clarity, it will be appreciated that two, three or more lugs may, in fact be disengaged before the closure is able to distort to provide the vent path). Further upward movement (not shown) of the pull-loop 40 causes the frangible connections 34 to begin to break. However, the circumferential shortening of the snap-fit projections 22b for the lugs 20b, and the axial shortening of the ridges 35a for the initial lug 20a, together combine to allow the initial lug 20a to flex outwardly without commencing peeling of the adjacent lugs 20b and the remaining lugs 20.

Finally, once the band 30 has been lifted fully, the closure can be peeled from the container mouth by using the band as a handle as in the first embodiment. Therefore, the closure is peeled from a position adjacent to the hinge web 32.

The size of the snap-fit projections 22b on the lugs 20b on either side of the initial lug 20a can be varied as desired to ensure, in practice, that flexing of the initial lug 20a to vent internal pressure does not cause the adjacent lugs 20b to begin peeling from the container mouth. In one possible modification, illustrated in Figs. 15 and 16, the projection may be omitted altogether from the lugs 20b, leaving instead a generally smooth non-interlocking surface. This would provide an optimum discontinuity interruption of any peeling effect from the initial lug 20a. However, complete removal of the snap-fit projection from the lugs 20b might weaken the overall engagement

between the closure and the container mouth, and reduce the maximum pressure which the closure is able to withstand prior to opening.

In Figs. 15 and 16, the closure 14 employs two hinge webs 32a and 32b instead of a single hinge web 32. The pull-loop 40 is positioned to be diametrically opposite the effective centre of the hinge webs, i.e. opposite the most central lug between the two hinge webs 32a and 32b. It will be appreciated that two or more hinge webs may be used in any of the preceding embodiments as desired.

If desired, the pull-loop 40 may be omitted from the embodiments illustrated in Figs. 9-16. The closure would still operate in a similar manner to that described above, but would rely on manually lifting the band 30, for example by thumb.

If desired, the further modifications illustrated in Fig. 8 may be incorporated into one or more of the lugs of the embodiments of Figs. 9-16 to further modify the characteristics of the closure.

A yet further embodiment of closure is illustrated in Figs. 17 to 24. Again, the same reference numerals are used in these drawings to denote features equivalent to those described previously. Although a closure liner is not shown explicitly in these drawings, it will be appreciated that a suitable liner may be used as desired (and that the liner may be integrally moulded as part of the closure if desired).

The closure 14 is similar to the previous embodiments, with the following differences and further developments:

(a) The closure is designed such that it can be easily moulded and ejected from a two-part mould;

(b) The closure and container are configured such that, the action of fitting the closure to the container mouth automatically stresses (tensions) the bracing band 30 to more firmly secure the closure to the container;

(c) The closure is designed such that the bracing band 30 interlocks with the closure when tensioned, to strengthen the bracing effect, and to permit progressive release of the bracing effect as the bracing band is lifted.

In more detail, referring to Fig. 17, the closure 14 is moulded using a two part mould comprising an upper mould part 50 and a lower mould part 52, the lower part 52 also including a central ejector 54. One of the difficulties in using a two-part mould is ensuring that the bracing ring 30 does not stick in the upper mould part 50 when the upper mould part 50 is moved away to open the mould. It will be appreciated that the lugs 20 of the closure 14 are interlocked with the lower mould part 52. Therefore, there is a danger that, if the bracing ring 30 sticks to the upper mould part 50 (as might happen in view of the relatively large contact surface area), the bracing ring 30 could be torn off the closure 14, and the closure 14 therefore destroyed. A further difficulty of using a two-part mould is the difficulty in removing the moulded closure from the lower mould part 52, without damaging the projections 22 of the segmented lugs 20. It will be appreciated that if the lugs 20 are damaged, then this could affect the performance of the closure 14, especially its ability to withstand high container pressures.

In the present embodiment, these problems are addressed in three ways.

Firstly, referring to Figs. 17 and 19, the bracing band 30 is, in this embodiment, configured to extend partly below the lowermost edge of the lugs 20. The confronting edge region 56 of the lower mould part 52 has a surface which is configured to grip the confronting surface of the bracing band 30. For example, the surface of the mould part 52 in the region 56 may be rough (e.g. shot blasted), or have an undercut, or be parallel to the direction of mould separation (in contrast to other surfaces which are designed not to provide retention).

Referring to Fig. 19, once the closure 14 has been moulded, the upper mould part 50 is moved upwardly away from the lower mould part 52. The effect of the rough surface region 56 is to tend to grip the bracing band 30 in the lower mould part 52, to ensure that the bracing band 30 does not remain in the upper mould part 50.

Secondly, (as best seen in Figs. 18 and 22), the frangible connections 34 between the bracing ring 30 and the lugs 20 are configured to be easily collapsible (without shearing) when subjected to a radial compression force. In this embodiment, the connections 34 are radiused. This permits the lugs 20 to move outwardly to some extent when the closure 14 is being ejected from the lower mould part 52, without the

bracing band 30 obstructing this limited movement. In other words, although the bracing band 30 is integrally moulded with the closure 14, the bracing band 30 does not itself fully brace the lugs 20 when in the mould, and therefore the ring 30 does not obstruct removal from the mould to the same extent as if the frangible connections 34 are made to be rigid.

Thirdly, the radial dimension of the projections 22 of the lugs 20 is generally smaller in this embodiment than in the previous embodiments. Typically, the radial dimension for this embodiment may be about 0.7 mm (or less), whereas the dimension for the previous embodiments would typically be about 1 mm or greater. It will be appreciated that a reduction in the radial dimension of the projections 22 can have an adverse effect on the locking engagement between the closure and the container, in use. However, as will be apparent from the description below, an improvement in the locking engagement is achieved by a further feature, and this permits the size of the projections 22 to be reduced without reducing the security of the closure in practice.

It will be appreciated that the reduction in the size of the projections 22 results in the closure being more easily removable from the lower mould part 52, as there is less of an interlock between the closure 14 and the lower mould part 52.

Referring to Figs. 19 and 23, once the upper mould part 50 has been removed, the central ejector 54 is then operated to lift the closure 14 off the lower mould part 52. The abutment surface 28 of the projection 22 of each lug 20 is inclined. As the ejector 54 lifts the closure 14, the effect of the inclined abutment surface 28 is to urge the lug 20 radially outwardly, such that the band 30 can separate cleanly from the rough mould surface region 56. As explained above, the closure 14 is configured to enable the lugs 20 to expand radially without initially being obstructed by the bracing band 30. However, as best seen in Fig. 23, the amount of free expansion of the lugs 20 is insufficient to disengage completely from the lower mould part 52. Therefore, the bracing band 30 expands slightly as the lugs 20 deform outwardly and bear against the band 30, and this slight expansion of the bracing band 30 is sufficient to ensure that the band 30 separates cleanly from the "gripping" surface 56 of the lower mould part 52.

Therefore, the closure can be removed easily from the two-part mould with very little risk of damage.

The moulded closure 14 is illustrated in Figs. 20 and 24. The lugs 20 are moulded to diverge or flare outwardly slightly. In this embodiment, the moulded angle of flare (relative to the axis 60 of the closure) is about 10°. The abutment surface 28 of each projection 22 is inclined at an angle of about 95° relative to the lug 20 (i.e. at an angle of about 15° relative to the radial direction, and about 75° relative to the axis 60). The lead-in ramp surface 26 of each projection 22 is inclined at an angle of about 15° relative to the axis 60 (i.e. the ramp surface 26 is generally perpendicular to the abutment surface 28).

In contrast, in Fig. 20, the rim 11 around the mouth of the container 10 has a surface 62 with a larger angle of flare than that of the lugs 20. In this embodiment, the angle of the surface 62 substantially matches the angle of the ramp surface 26, i.e. about 15° relative to the axis 60. The matched angles can ensure that, when the closure is initially placed loosely on the rim 11, the closure 14 will rest squarely (i.e. level) on the rim.

To secure the closure 14, a pressure head (not shown) is advanced to press the closure downwardly on to the rim 11. As the closure 14 is pressed downwardly (Fig. 21), the lugs 20 are forced outwardly to enable the projections 22 of the lugs 20 to snap into engagement over the rim 11, in the same manner as that for the previous embodiments.

However, an important feature of this embodiment is that the surface 62 retains the lugs 20 in a slightly outwardly deformed state (as best seen in Fig. 21). The angle of flare of the surface 62 is about 15°, and so the lugs 20 are forced outwardly from their moulded 10° position by about a further 5°. In this state, the lugs 20 are expanded outwardly so that the ridges 35 of each lug 20 bear directly against the bracing band 30. The band 30 is therefore now under tension, and acts to directly brace the lugs 20. As best seen in Fig. 22, the frangible connections 34 collapse (without shearing) to accommodate the expansion of the lugs 20, in the same manner as that described previously (during mould release).

Therefore, the band 30 is automatically placed under tension to brace the lugs 20 by the action of fitting the closure 14 to the rim 11 of the container. This effect is achieved by the outward expansion of the lugs 20, caused by the different

configuration of the container rim 11 relative to that of the lugs 20 (as originally moulded).

The creation of tension in the bracing band 30 provides the increased security referred to above, which enables the radial size of the locking projections 22 to be reduced. The corresponding abutment surface 64 of the container rim 11 is configured to match the shape of the abutment surface 28 of the projection 22, and is inclined at an angle of about 20° to the radial direction (i.e. the abutment surface 64 is inclined at an angle of about 70° relative to the axis 60, and at angle of about 95° relative to the ramp surface 62). This ensures that, in the expanded condition of the lugs 20, the abutment surfaces 28 of the projections 22 lie in parallel face-to-face contact with the abutment surface 64 of the container rim 11, for optimum locking engagement.

It will be appreciated that the small size of the abutment surfaces 28 of the closure 14 also means that the abutment surface 64 of the container rim 11 is corresponding small, leading to a more aesthetically acceptable appearance of the container. The small size is also important for beverage containers from which a person may wish to drink the contents directly.

The various surface angles described above also act to provide advantages in terms of seal performance and ease of opening. As best appreciated from Fig. 21, any force exerted on the closure 14 by pressurised container contents will be transmitted through the inclined lugs at an angle of 15° (indicated by force arrow 66) relative to the axis 60. The abutment surfaces 28 and 64 are not perpendicular to this direction, and so there will tend to be some ramp effect (tending to urge the closure open), as in the previous embodiments. However, since the abutment surfaces 28 and 64 are inclined at an angle of about 70° relative to the axis 60, the effective "ramp" angle is very steep at about 85°, i.e. very close to perpendicular, such that the ramp effect is very small.

In contrast, when a user applies an external force to lift the closure 14 when opening the container (once the bracing band 30 has been moved away), the lifting force is generally axial (as indicated by force arrow 68). The effective "ramp" angle for an axial force 68 (instead of a force 66 at 15°) is much shallower at about 70°, leading to a much greater ramp effect to ease the lugs 20 off the rim 11.

It will be appreciated that the above contrasting effects result from the different directions of force on the lugs 20 indicated by force arrows 66 and 68.

As best seen in Figs. 18 and 22, the bracing band 30 further comprises a plurality of interlock projections 70 on the radially inner surface of the band 30. In the present embodiment, there is a respective interlock projection 70 positioned in register with each lug 20 (except for any lugs associated with the hinge). The interlock projections 70 are dimensioned to fit between adjacent ridges 35 when the lugs 20 are expanded, so as to lock the band 30 and lugs 20 together, as described below.

The effect of the interlock projections 70 is important when the closure 14 is subjected to extremely high container pressure. Without the interlocking projections, if an individual segment starts to deform radially outwardly, there is maybe a risk that the whole band might move circumferentially and stretch sufficiently to enable the lug to become completely disengaged, and the closure to fail. However, with the interlocking projections 70, the bracing band 30 is anchored to the lugs, and is not free to move or stretch relative to the lugs over its entire length. Instead, if a lug begins to deform outwardly (risking failure), the bracing band 30 can only move and stretch locally in the vacinity of the lug. This effectively stiffens the band, and increases significantly the strength of the bracing effect, leading to better closure performance. In effect, if there are 14 lugs 20 each coupled to the bracing band 30 with a suitable mechanical interlock 70 able to withstand torsional loads, then the strength of the bracing effect can be increased considerably.

Furthermore, when the user begins to lift the bracing band 30 to remove the closure 14 from the container 10 for the first time, the interlock projections 70 serve to release the bracing effect progressively in a controlled manner around the periphery of the closure as the bracing band is lifted progressively higher. For each lug 20, once the bracing band 30 has been lifted above the ridges 35, that lug 20 is no longer braced. However, an adjacent lug which is still engaged by an interlock projection 70 can still be braced, to ensure that the lugs are released progressively.

This can provide an important safety feature for pressurised containers in ensuring that the closure is not vulnerable to being blown off the container mouth as the bracing band is lifted out of the bracing position. Equivalent interlock projections

70 may also be used with any of the previously described embodiments to provide the closure with similar increased strength and progressive-release characteristics.

As in the previously described embodiments, when the bracing band 30 is lifted for the first time to release the closure 14, the frangible connections 34 shear to provide a tamper evident characteristic. In the event that the frangible connections might not easily be seen, the user will still be able to feel and hear the frangible connections breaking, as evidence that the closure has not been tampered with.

As can be clearly seen in Figs. 20 and 21, the bracing ring 30 has a generally rectangular cross-section (in contrast to a more rounded cross-section used in the earlier embodiments). Particularly for pressurised containers, the rectangular shape can avoid any tendency for the bracing band 30 to "pivot" or "roll" upwardly when the lugs 20 are withstanding a high internal container pressure. The present embodiment is also designed such that it is difficult for the bracing band 30 to be re-lowered into its bracing position once the closure has been opened for the first time (to improve the tamper-proof characteristics of the closure). The rectangular section of the bracing band 30 makes the band difficult to manoeuvre back on to the ridges 35.

A yet further embodiment is illustrated schematically in Fig. 25. In contrast to the previous embodiments in which the rim 11 of the container mouth 12 includes only a single undercut, in the present embodiment the rim includes a plurality of axially spaced annular undercuts 72. The lugs 20 of the closure 14 likewise include a plurality of locking projections 74 to match the undercuts 72 of the container rim 11. By using multiple engagement profiles, the engagement force can be spread over a larger region, and the radial dimension of each respective undercut 74 and locking projection 22 can be reduced, providing an improved drinking container finish. This embodiment is also more easily ejected from the mould core after moulding, as the lugs 20 are required to move less to clear the lower mould part 52 than, for example, the previous embodiment.

It will be appreciated that the invention, particularly as illustrated in the preferred embodiments, can provide a closure which can withstand large forces, yet is also easy to remove when desired. The closure is also easy to produce, and easy to fit to container mouths. Although the invention is not limited to wide mouth containers,

this is an application for which the closure is especially suitable. Similarly, although the invention is not limited only to pressurised containers, this is also an application for which the invention is especially suitable.

It will be appreciated that the foregoing description is merely illustrative of a preferred form of the invention, and that many modifications may be made within the scope of the invention.

Features believed to be of importance are defined in the appended claims. However, the Applicant claims protection for any novel feature or idea described herein and/or illustrated in the drawings whether or not emphasis has been placed thereon.